Single Photon Sources for Free Space Quantum Key Distribution Systems

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Description:
OBJECTIVE: Develop and demonstrate an on demand single photon source for use in a free-space Quantum Key Distribution (QKD) satellite to ground configuration. DESCRIPTION: Security in quantum key distribution (QKD) arises from the principle that the quantum state of a single photon, prepared in an unknown basis, can only be determined with a probabilistic outcome. This fact both limits the information that may be gleaned by an eavesdropper and allows eavesdropping to be detected via errors that are introduced into the quantum channel. In practice, attenuated laser pulses are often employed as a photon source and offer a wide range of useful spectral and temporal characteristics. However, the photon number of such pulses is described by Poissonian statistics and necessarily includes multi-photon pulses. The pulses that contain multi-photons can in principle be exploited by an eavesdropper to gain information without detection. Recent developments in non-Poissonian photon sources suggest that it may be possible to minimize or eliminate the risk of multi-photon pulses for use in QKD. In order to be useful in a free-space QKD scenario that includes atmospheric propagation, a non-Poissonian source would need to be developed with the following characteristics: 1. The 2nd order coherence function, g(2), should approach zero. 2. The center wavelength should lie within an atmospheric transmission band and within a region of high detector quantum efficiency. 3. The spectral emission width should be of the order of 1 GHz. 4. The controlled emission timing jitter should be less than 100 picoseconds. 5. The temporal emission width should be less than 1 nanosecond. 6. The emission rate should be greater than 1 MHz. 7. The source should be directional with near-diffraction-limited wavefront quality. Desirable sources will be controllable and emit a

single photon"on demand"at an arbitrary user-specified time with very low probability of zero or multi-photon emission. Sources will produce narrowband single photon emission in the spectral range of 750 1600 nm at a rate of = 1MHz or higher. The source should be compatible with free space propagation in the Earth"s atmosphere (space-to-ground links) and compatible with corresponding developments with single photon detector technologies. The use of narrowband emission allows for spectral filtering for daytime use. To be most effective this source should show a high contrast in antibunching (single photon emission), exhibit high quantum efficiency, show extreme photostability (photoluminescence stability (i.e., no photobleaching) and/or extreme electrostability (electroluminescence stability). To be extensively used, this source should be robust and capable of packing for airborne or space platforms. PHASE I: Design an on-demand single photon source capable of producing: narrowband photon emission in the spectral range 750-1600nm; single photons at a rate of = 1 MHz. Approach should include a detailed design description & supporting physics based analysis to demonstrate achievement of sub-Poissonian statistics. Prepare a plan for prototype development & testing & determine DoD application feasibility. PHASE II: Prepare and test prototype single photon source with high emission rates, high contrast antibunching and efficiency, photostability and electrostability. Demonstrate achievement of sub-Poissonian statistics by intensity autocorrelation measurements of g(2). Identify packaging and systems integration issues for operation in a LEO environment. PHASE III DUAL USE APPLICATIONS: Military: Encryption technologies are needed for all DoD & NRO spacecraft & many other operational systems. Commercial satellites and ground system will benefit in the same manner as military spacecraft from this technology. Future quantum communications systems will also be derived from this research.